FOUNDATIONS OF THE COMPOSITE DIFFRACTED EVANESCENT WAVE MODEL

ARISING FROM: G. GAY *ET AL. NATURE PHYS.* **2,** 262–267 (2006)

To the Editor — In the paper by Gay *et al.* in the April 2006 issue of *Nature Physics*[1], an experimental investigation of the light transmission through a two-dimensional system composed of one slit and one indentation drilled on a silver film is carried out. The results were analysed within the composite diffracted evanescent wave (CDEW) model. This comment demonstrates that the mathematical foundation of the CDEW model is flawed.

Our first criticism is that CDEW model is based on a scalar calculation that cannot deal correctly with systems where polarization of light is a key ingredient. To illustrate this point, we have carried out finite-difference time-domain calculations on the two-dimensional structure analysed by Gay *et al.*[1] (see Fig. 1a). Under normal incidence the two polarizations *s* (**E**-field along the *y* direction, **H**-field in the *x*–*z* plane) and *p* (**H** along the *y* direction, **E** in the *x*–*z* plane) are decoupled. Figure 1b renders the calculated optical transmission (normalized to the single-slit transmission) as a function of the slit–groove distance, for both *s* (red line) and *p* (blue line) polarization. These calculations, which for *p*-polarization are in very good agreement with the experimental data reported in ref. 1, show that for *p*-polarized light the electromagnetic coupling between slit and groove produces noticeable effects on the transmission, whereas for *s*-polarization this coupling is negligible.

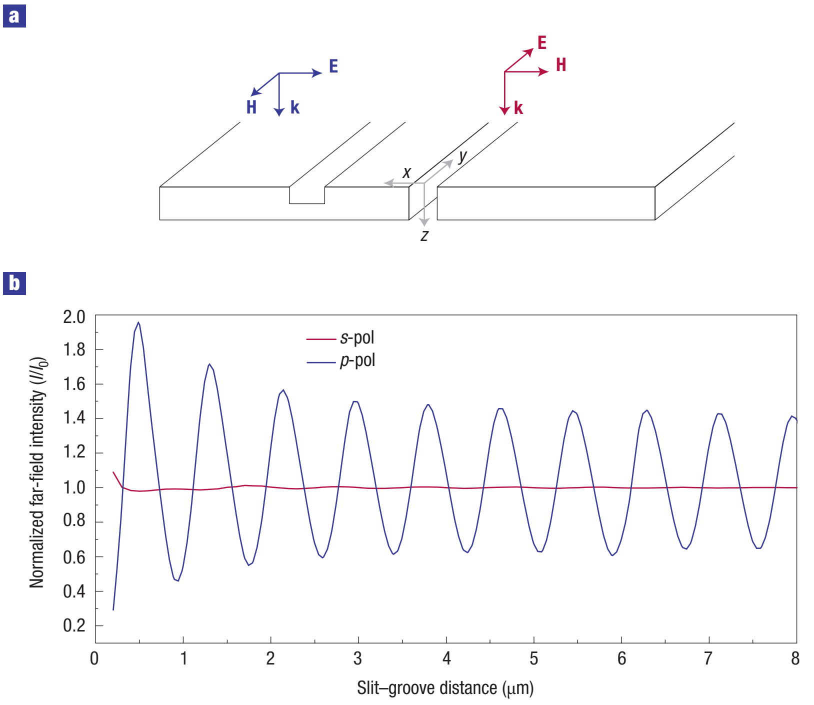

Figure 1 Optical response of a proximal slit and groove. a, Schematic picture of the structure analysed by Gay *et al.*[1] and the two possible polarizations (*s* and *p*) of the normally incident light. The structure consists of a one-dimensional slit and a groove perforated on a silver film. **b**, Calculated optical transmission through the structure depicted in **a** as a function of the slit–groove distance. For each polarization, *s* (red curve) and *p* (blue line), the transmission is normalized to the single-slit case. Dielectric data for silver, wavelength (λ = 852 nm) and the geometrical parameters (width of slit and groove 100 nm, depth of groove 100 nm and thickness of silver film 400 nm) are taken from ref. 1. Discretization mesh is 5 nm.

The CDEW model approximates the electric field at the groove location as the one emerging from a single slit perforated in an opaque screen. This electric field is taken from the scalar diffraction calculation reported by Kowarz[2]. As the slit–groove electromagnetic coupling depends strongly on polarization, a calculation based on scalar diffraction, for a given boundary condition, could be a good approximation for either *s*-polarization or *p*-polarization (or none!), but obviously not for both cases. The boundary condition applied in ref. 2 is that the scalar field is zero at the screen. For *s*-polarization this condition applies to E_y (the only non-zero component of the **E**-field) whereas for *p*-polarization it is compatible with E_x but not with E_z. In fact, E_z, which is not null at the surface, is the relevant component that controls the electromagnetic coupling at the surface for *p*-polarization (if E_x were the relevant component, the results shown in Fig. 1 would be the same for *s*- and *p*-polarization). Therefore, the CDEW model may be appropriate for *s*-polarization but, as E_z is not properly described by the scalar calculation in ref. 2, it completely mishandles *p*-polarization.

The second criticism is that, even within the scalar theory, the CDEW model is wrong. As clearly stated in ref. 2, the scattered electromagnetic field has contributions from both evanescent and radiative modes. However, in deriving the CDEW model only the contribution from evanescent modes is, arbitrarily, taken into account. Neglecting the contribution from radiative modes is a serious mistake: at the surface this contribution exactly cancels the one coming from evanescent modes[2], as must be the case in order to fulfil the imposed boundary condition. It is not surprising that the CDEW model results only agree with experimental data after several fitting parameters have been accommodated into the model.

To summarize, the CDEW model has both incorrect mathematical and physical foundations. Any argument based on this model is, therefore, invalid.

REFERENCES

1. Gay, G. *et al. Nature Phys.* **2,** 262–267 (2006).
2. Kowarz, M. W. *Appl. Opt.* **34,** 3055–3063 (1995).

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